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Research Document 2000/052 | **Document de Recherche 2000/052**

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The Jonah Crab, *Cancer borealis*, Fishery in Canadian Offshore Lobster Fishing Area 41, 1995 to 1999

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This document is available on the Internet at: Ce document est disponible sur l'Internet à:
http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2000

Canada

ABSTRACT

The evolution of an exploratory offshore Jonah crab, *Cancer borealis*, by-catch fishery is reviewed from its inception during the 1994-95 fishing season (seasons run from October 16 of one year to October 15 of the following year) to the most recent season (1998-99). During 1995, the offshore lobster industry reached an agreement with the Department of Fisheries and Oceans to fish Jonah crab as a by-catch to offshore lobster with its eight fishing vessels. Fishing for Jonah crab was limited to the traditional offshore lobster fishing grounds in 4X, and landings were not to exceed the 720 t quota set for offshore lobster. Offshore lobster traps were to be used and only males larger than 130 mm (carapace width, CW) could be retained.

Fishing effort was concentrated on Georges and Southwest Browns banks during 1994-95, but expanded to cover all offshore lobster assessment areas during the 1996-97 season. Overall catch increased until the 1996-97 fishing season, when the quota was essentially reached at 707 t. From 1996-97 to 1998-99, fishing effort remained relatively constant between 221,385 and 253,051 reported trap hauls. At present, fishing effort is concentrated in Crowell Basin, and on Southeast Browns and Southwest Browns banks. Effort decreased substantially on Georges Bank from initial levels, and landings declined from a high of 322 t in 1996-97 to 47 t in 1998-99. The 1998-99 catch rates were highest in Crowell Basin (4.6 kilograms per trap haul, kg/th), followed by Georges Basin (2.6 kg/th). Overall catch rate peaked during the 1995-96 season at 4.2 kg/th, then fell to a relatively constant level (from 2.9 to 3.2 kg/th) during the last three fishing seasons.

Average size of crabs measured at sea varied between areas and between months and did not show any clear annual or seasonal trend. The percentage of legal size male crab varied between 54 and 92%, and was generally highest in Crowell Basin.

The recent decline in landings and catch rate on Georges Bank, and to a lesser extent on Southeast Browns Bank, is attributed to a shift of effort to the more lucrative lobster fishery. Potential interaction with the developing inshore exploratory fishery for Jonah crabs, and the by-catch provision for this crab in the inshore lobster fishery, is discussed. Biological and fishery information indicates that a cautious approach should be taken if the long-term goal is to maintain a fishable stock. The catch rates, behavior of the fishery, and the size structure of the stock should continue to be monitored through logbooks, dockside monitoring and at-sea sampling.

RÉSUMÉ

On passe en revue l'évolution d'une pêche accessoire exploratoire du crabe nordique, *Cancer borealis,* en haute mer à partir de son ouverture pendant la saison de pêche 1994-1995 (les saisons vont du 16 octobre d'une année donnée au 15 octobre de l'année suivante) jusqu'à la saison la plus récente (1998-1999). En 1995, l'industrie de la pêche hauturière du homard a conclu une entente avec le ministère des Pêches et des Océans visant à permettre aux huit bateaux de pêche du homard de récolter des prises accessoires de crabe nordique. En vertu de l'entente, le crabe nordique ne pouvait être pêché que dans les pêcheries hauturières traditionnelles du homard dans 4X et les débarquements ne pouvaient dépasser le quota hauturier établi de 720 t de homard. Les pêcheurs devaient en outre utiliser des casiers de pêche hauturière du homard et seuls les mâles de plus de 130 mm (largeur de la carapace) pouvaient être gardés.

En 1994-1995, l'effort de pêche était concentré sur Georges Bank et le sud-ouest de Browns Bank, mais s'est étendu de sorte à couvrir l'ensemble des zones hauturières d'évaluation du homard pendant la saison 1996-1997. Le total des prises a augmenté jusqu'à la saison de pêche de 1996-1997, lorsque le quota a essentiellement été atteint, les prises se chiffrant à 707 t. De 1996-1997 à 1998-1999, l'effort de pêche est demeuré relativement constant, le nombre signalé de casiers relevés se situant entre 221 385 et 253 051. À l'heure actuelle, l'effort de pêche est concentré dans Crowell Basin et sur le sud-est et le sud-ouest de Browns Bank. L'effort a nettement diminué sur Georges Bank par rapport aux niveaux initiaux, et les débarquements ont chuté d'un pic de 322 t en 1996-1997 à 47 t en 1998-1999. Les taux de capture les plus élevés en 1998-1999 ont été obtenus dans Crowell Basin (4,6 kg par casier relevé), suivi du Georges Bank (2,6 kg par casier relevé). Le taux de capture global a atteint un pic de 4,2 kg par casier relevé en 1995-1996, pour ensuite chuter et se maintenir à un niveau relativement constant (se situant entre 2,9 et 3,2 kg par casier relevé) durant les trois dernières saisons de pêche.

La taille moyenne des crabes mesurés en mer variait selon la zone et le mois et ne montrait aucune tendance annuelle ou saisonnière claire. Le pourcentage de crabes mâles de taille légale, généralement plus élevé dans Crowell Basin, variait entre 54 et 92 %.

La récente baisse des débarquements et du taux de capture sur Georges Bank et dans une moindre mesure sur le sud-est de Browns Bank est imputable à une réorientation de l'effort vers la pêche du homard, plus rentable. On étudie l'interaction potentielle avec la pêche côtière exploratoire du crabe nordique en développement et la disposition relative aux prises accessoires de cette espèce dans le cadre de la pêche côtière du homard. Les données sur la biologie et la pêche indiquent qu'une approche de prudence est de mise si l'objectif à long terme est de maintenir un stock exploitable. On devrait en outre continuer à surveiller les taux de capture, l'évolution de la pêche et la structure de la taille du stock en utilisant les registres de pêche, la vérification à quai et l'échantillonnage en mer.

INTRODUCTION

Biological Background

Jonah crab, *Cancer borealis*, can be found from Newfoundland to Florida, and in the Bermudas at depths ranging from the intertidal to 800 m (Haefner 1977; Wenner et al., 1992). Off Nova Scotia the crabs are found primarily at depths of 50-300 m and temperatures of 8-14 °C. The habitat occupied by Jonah crab apparently changes along its geographical range, from rocky substrates in Narragansett Bay (Jeffries 1966) and off the coast of Maine (Krouse. 1980), to silt and clay off the continental slope (Musick and McEachran 1972; Wenner et al., 1992). Haefner (1977) suggested that migration of Jonah crab was limited in the Middle Atlantic Bight. However, Jeffries (1966) reported inshore movement from spring through fall, followed in winter by emigration to deeper, warmer waters off Rhode Island. Carpenter (1978) reported size and sexual segregation with depth in Norfolk Canyon where smaller-sized (<30 mm carapace width, CW) females were dominant at depths less than 150 m, and males were most abundant at depths over 150 m.

There is very little biological information available on Jonah crab in waters off Nova Scotia. Knowledge of Jonah crab life history is geographically limited to waters off New England and Chesapeake Bay (Wenner et al., 1992). In Norfolk Canyon, off the mouth of Chesapeake Bay, Virginia, males are mature at 90-100 mm CW and female Jonah crabs mature at 85 mm CW (Carpenter, 1978). Preliminary analysis of Jonah crab maturity on the Scotian Shelf has shown that morphometric maturity (or functional maturity) of 50 % of the males examined occurred at 128 mm CW (Moriyasu et al., in prep). This size at maturity is much larger than the previous assumption of 110 mm CW (Benhalima et al., 1998). The estimated size of 50% maturity for females occurred at 92 mm (CW) (Benhalima et al., 1998).

Males can reach a maximum carapace width of approximately 180 mm with a weight of 0.9 kg. Females usually do not exceed 150 mm CW and 0.5 kg in weight (Elner, 1986). Ovigerous females as small as 65 mm CW have been reported on the Scotian Shelf. Ovigerous females have been found during August and September in Maine and in mid-July in Narragansett Bay. Carpenter (1978) suggested a spawning period during late winter to early spring in the Middle Atlantic Bight.

Fisheries Development

Since the 1960's Jonah crab stocks have been exploited as a trap by-catch to inshore and offshore lobster fisheries (Appendix 1). Accurate landing figures are not available from these early fisheries. In the early 1980's an experimental Jonah crab fishery concentrating in LaHave and Emerald Basins on the Scotian Shelf lasted only two years (Elner and Robichaud, 1984; 1985). Average catch rates were 6.6 kg/th in 1983 and 13.3 kg/th in 1984, before poor economic conditions resulted in fishery closure. The last directed research trapping surveys for Jonah crab were conducted in 1981 prior to the Jonah crab fishery of 1983 and 1984 (Appendix 1).

Through the subsequent years the Offshore Lobster Industry periodically landed some Jonah crab as a by-catch to the lobster fishery. In the latter part of 1995, a proposal from the Offshore Lobster Industry to land Jonah crab on a regular basis (as a by-catch to the lobster fishery) was approved. The agreement, which is still adhered to today, limits Jonah crab catch from eight offshore lobster fishing vessels to the historical offshore lobster assessment areas in 4X as shown in Fig. 1 (Pezzack et al., 2000). The fleet is limited to a male only Jonah crab fishery with a minimum size limit of 130 mm CW. The gear type in use is an offshore lobster trap. A yearlong crab season was set to begin on the 16th of October (same date as the offshore lobster season). A quota for the offshore Jonah crab by-catch fishery was fixed so as not to exceed the 720 t quota set for offshore lobster. A program funded by industry provides samplers for the collection of biological samples at-sea. The industry also provides fishery data through completion of logbooks with catch and effort information. A single exploratory license was also issued in 1994 to direct for Jonah crab in the NAFO 4W portion of LFA 41. However, data on the fishing activities of this license are not included in this report.

ASSESSMENT METHODOLOGY

Fishery Data

A detailed logbook, developed by DFO Science staff, was supplied to the captains of offshore lobster vessels for completion when catches included Jonah crabs. For each trip general information on trip number, vessel name, CFV number, vessel captain, number of crew, trap type with entry design, and trap size was recorded. On a string by string basis, the captains were asked to provide detailed information on date, location in latitude and longitude or Loran C, depth range in fathoms, number of days gear set, number of traps hauled, and estimated weight in pounds of crabs and lobsters retained. In 1998 mandatory dockside monitoring documents (DMD) were introduced, and all trips were dockside monitored. Considering that similar information on fishing activity was collected both on the DMD documents and science logbooks, the science log was discontinued. For the 1998-99 season DMD logs have been the main source of information for the Offshore Jonah crab fishery. Logbooks and dockside monitoring documents were used to provide catch and effort information from which catch rate was estimated. Landings and catch rates were calculated based on each trip that reported crab landings regardless of the amount of lobster by-catch during those same trips. Offshore crab logbook data was entered on a georeferenced relational database and analyzed using geographic information system software.

Biological Data

A sea-sampling program, funded by industry, was initiated in 1995. Size frequency samples were collected monthly from each offshore assessment area during periods corresponding to the highest crab fishing effort. These monthly sea samples provided information on size (carapace width, CW, in millimeters, mm) of both males

and females, and biological information on shell hardness, egg color, and number of berried females. In addition, general information such as vessel name, captain, port, location, depth range, gear type, date, string number, sampler name and surface temperature if available was recorded. The carapace width was determined by measuring the width of the carapace across the widest part, from tip to tip of the most distal marginal teeth (Elner and Robichaud, 1984). Furthermore, a sea sampling log was completed for all sea samples. The size frequency data recorded at-sea was submitted with original data sheets to DFO Science for entry into an oracle database. The size data was then grouped by fishing areas, month and sex, and size frequency by 1mm groupings were produced.

RESULTS AND DISCUSSION

Fishing Patterns & Catch and Effort

Catch and effort information, obtained from fishermen's logbooks, describes the evolution of the Offshore Jonah crab by-catch fishery during the last five fishing seasons (Fig. 2; Table 1). During the 1994-95 season (Oct. 16/94-Oct. 15/95), fishing for Jonah crab began in June 1995 (Fig. 3). Four of eight offshore vessels landed 39 t of Jonah crab. Fishing effort was directed mostly on Georges Bank and Southwest Browns with some effort on Southeast Browns (Fig. 2). For all areas combined, the overall catch rate was 3.2 kg/th (Table 1). The highest overall catch rate (4.5 Kg/th) and most of the landing (31 t) came from Georges Bank. The monthly catch rates on Georges Bank for September and October varied between 4.3 and 4.5 kg/th compared to monthly catch rates for August to October of between 1.0 and 2.2 kg/th on Southwest Browns (Figs. 3 & 4).

During the 1995-96 season, seven of eight offshore vessels landed 356 t of Jonah crabs (Table 1). Ninety six percent of landings occurred between July and October 1996 (Figs. 2 & 3 & 4; Table 1). No fishing for Jonah crab took place between December 1995 and June 1996. Fishing effort increased in three Offshore Lobster Fishing Areas with most of the increased effort directed to Georges Bank and Southeast Browns and to a lesser extent on Southwest Browns (Fig. 2). Overall landings increased ninefold and effort increased sevenfold to a total of 85,288 trap hauls. Overall catch rates increased in all areas (Table 1). Jonah crab landings and overall catch rates were highest on Georges Bank (230 t and 6.7 kg/th). Substantial landings were also reported for Southeast Browns (84 t), Southwest Browns (25 t) and Crowell Basin (14 t). However the overall average catch rates for Southeast Browns (2.8 Kg/th), Southwest Browns (1.6 kg/th) and Crowell Basin (3.5 kg/th) were lower than Georges Bank (6.7 kg/th). Monthly catch rates between July and October on Georges Bank varied between 5.6 & 8.8 kg/th compared to monthly catch rates of between 2.1 & 4.1 kg/th on Southeast Browns, between 1.2 & 1.9 kg/th on Southwest Browns and between 2.8 & 5.4 in Crowell Basin (Figs. 3 & 4).

During the 1996-97 season the Offshore Lobster fleet fished for Jonah crab during all months of the fishing season (Fig. 3). Seven of eight vessels reported landings of 707 t (98 % of the quota) of Jonah crab (Table 1). Effort increased by 186% and the overall catch rate from all areas combined decreased by 31 % from the previous year (from 4.2 to 2.9 kg/th) (Fig. 2, Table 1). Most of the expansion of effort occurred on Georges Bank and Southeast Browns. There was also a noticeable increase in fishing effort on Southwest Browns and Crowell Basin (Fig. 2).
The highest overall catch rates and landings were found in Crowell Basin (5.1kg/th; 161 t) and Georges Bank (4.1 kg/th; 322 t). In Crowell Basin, 99% of Jonah crab were landed between June and October 1997 (Figs. 3 & 4). The overall mean catch rate of 5.1 kg/th (monthly catch rates varied between 3.9 and 5.9 kg/th) was approximately 1.5 times higher than that of the previous year (3.5 kg/th) during a similar time period (July-October, 1996). This increase in catch rate in Crowell Basin was in contrast to the decline of the overall catch rate that occurred on Georges Bank (from 6.7 to 4.1 kg/th) and on Southeast Browns (from 2.8 to 1.5 kg/th). In these two areas Jonah crab were landed throughout the year and monthly landings varied between 1.8 to 6.4 kg/th on Georges Bank and between 0.8 and 2.3 kg/th on Southeast Browns (Figs. 3 & 4). Even though the overall catch rate decreased on Southeast Browns, the total Jonah crab landings from this bank almost doubled to 125 t. On Southwest Browns, landings (74 t) were almost three times that of the previous year (25 t). However the overall catch rate remained the same (1.8 kg/th) compared to the previous year (1.6 kg/th). Monthly variability in catch rate was larger during the 1996 -97 season (0.3 to 4.4 kg/th) compared to the 1995-96 season (1.2 to 1.9 kg/th) (Figs. 3 & 4).

During the 1997-98 season, two of the offshore lobster boats exclusively targeted Jonah crab. Ninety eight percent of the quota (702 t) was landed and the overall catch rate from all areas combined increased from 2.9 kg/th to 3.2 kg/th (Table 1).

On Crowell Basin total effort (33,631 to 70,694 th) and landings (from 161 t to 316 t) more than doubled. In comparison to the previous two fishing seasons, Jonah crabs were landed throughout all months of the fishing season. However the variability in the monthly catch rates (3.3 to 5.8 kg/th) throughout the season was similar to that of the previous year (3.9 to 5.9) between June and October 1997 (Figs. 3 & 4). Overall the catch rate decreased from the previous year from 5.1 kg/th to 4.5 kg/th.

In Georges Basin, effort (8,800 to 29,203 th) and landings (26 t to 85 t) more than triple that of the previous year. The catch rate remained the same as the previous year (2.9 kg/th) (Figs. 2 & 3: Table 1). The monthly catch rates varied substantially between 0.3 and 6.8 kg/th (Figs. 3 & 4).

In contrast, effort substantially decreased in the other three fishing areas. The largest decrease in effort occurred on Georges Bank (79,155 to 29,600 th) (Figs. 2 & 3). The Georges Bank area experienced a large decline in landings (from 322 t to 95 t) and catch rate (from 4.1 to 3.2kg/th) (Table 1). Ninety two percent of Jonah crabs were landed between May and September 1998, and the monthly catch rates

for that time period varied between 2.5 and 4.1 kg/th. No effort was deployed on Georges Bank between the months of December 1997 and March 1998 (Fig. 3).

On Southwest Browns, effort declined from 41,099 th to 33,148 th and Jonah crab landings and catch rate remained similar to that of the previous year (from 74 t to 70 t and from1.8 to 2.1 kg/th) (Figs. 2, 3 & 4; Table 1). The monthly catch rates varied between 0.2 and 3.8 kg/th. No effort was deployed on Southwest Browns between February and April 1998.

On Southeast Browns, both landings (125 t to 135 t) and catch rate (1.5 to 2.3 kg/th) increased. There was also an increase in the variability in the monthly catch rates (0.6 to 3.4 kg/th) compared to that of the previous year (0.8 to 2.3 kg/th) (Figs. 3 & 4).

During the 1998-99 season, 97% of the quota was landed (697 t) and the overall catch rate decreased from 3.2 to 2.8 kg/th (Table 1). Small decreases in effort occurred on Southeast Browns (58,740 to 63,751 th) and Georges Bank (29,600 to 21,899 th) (Fig. 2; Table 1). However, on Southeast Browns (136 to 99 t; 2.3 to 1.5 kg/th) and Georges Bank (95 to 48 t; 3.2 to 2.1 kg/th) important declines in landings and catch rates occurred (Table 1). On Southeast Browns, the monthly catch rates was noticeably lower in the later part of the fishing season (June to October 1999) (0.5 to 0.7 kg/th), in comparison to the first part of the season (October 1998 to May 1999) (1.4 to 2.7 kg/th) (Figs. 3 & 4).

There was a small decline in landings (316 to 296 t) and effort (70,694 to 64,220 th) in Crowell Basin (Table 1). However the overall catch rate remained the same (4.5 to 4.6 kg/th). Monthly catch rates varied between 3.8 and 7.2 kg/th (Figs. 3 & 4). In contrast landings (70 to 168 t) and effort (33,148 to 69,206 th) more than double on Southwest Browns and the overall catch rate increased slightly from 2.1 to 2.4 kg/th. The monthly catch rates varied between 1.2 and 3.8 kg/th. There was also a slight increase in landings (85 to 88 t) and effort (29,203 to 33,975 th) (Figs. 2 & 3; Table 1) in Georges Basin. However the overall catch rate declined slightly from 2.9 to 2.6 kg/th (Table 1). Monthly catch rates varied between 0.9 and 4.6 kg/th (Figs. 3 & 4).

Total offshore Jonah crab fishing effort (summed across all assessment areas) has exceeded 200,000 trap hauls each fishing season since 1996/97, with a peak of 253,051 th during the 1998-99 season (Table 1). However, fishing effort on Georges Bank, after peaking at 79,155 th during the 1996-97 season, has declined by 72% during the last two seasons, to a low of 21,899 th. The most serious decline in effort and catch rate occurred on Georges Bank and to a lesser extent on Southeast Browns (Table 1). Landings and catch rates in Georges Basin, Southwest Browns, and Crowell Basin have remained relatively stable during the last three years. However, there are concerns of a substantial increase in effort in the Crowell Basin area, both by the offshore Jonah crab fishers (LFA 41) and the inshore lobster (LFA 34) fishers (Robichaud et al., 2000). During the past inshore lobster fishing seasons, an important increase in Jonah crab by-catch occurred, although it was not fully

reported (Robichaud et al., 2000). While most of the more productive fishing grounds are exploited, marginal fishing grounds with lower catch rates were explored. After five years of exploration the offshore Jonah crab by-catch fishery has probably reached it's full potential.

Size Composition

This fishery directs for male crabs, and thus, due to trap configurations and targetting of specific geographical areas, at-sea sampling of commercial catches provided only limited information on female crabs. Jonah crabs were sampled from depths ranging from 110 to 311 m. The overall size range of crabs sampled was 41 - 222 mm CW for males, and 40 - 188 mm CW for females. The monthly mean size varied between 128 to 148 mm CW for males and between 105 and 126 mm CW for females.

In Crowell Basin, between August 1997 and August 1999, the monthly mean size of males varied between 129 and 146 mm CW (Fig. 5; Table 2). Female monthly mean sizes varied between 110 and 123 mm CW (Fig. 5; Table 3). The proportion of females in the catch was the highest between August and October (26 to 45 %) compared to the period between March and July (1 to 3%). No monthly or seasonal trend in mean size was discernable for both males and females.

On Southwest Browns, the monthly mean size of males varied between 128 and 146 mm CW and no trend was discernible (Fig. 6; Table 2). Although the proportion of females in the catch was higher (11 to 50 %) the monthly mean size of females varied in the same range as on Crowell Basin (110 to 123 mm CW) (Fig. 6; Table 3).

In Georges Basin, because effort has only been sporadic during the last two years, only two samples have been taken (Fig. 7; Tables 2 & 3). The mean size of males was 141 mm CW in April 1998 and 148 mm CW in August 1999 and the mean size of females were 107 and 124 mm CW respectively. The proportion of females in the catch varied between 2 and 10%.

On Southeast Browns, the monthly mean size of males varied between 126 and 141 mm CW (Fig. 8; Table 2). The monthly mean size of females varied between 110 and 123 mm CW (Fig 8; Table 3). The proportion of females in the catch varied from 1 to 52 % and there was no discernible pattern.

On Georges Bank monthly mean size of males varied between 135 and 143 mm CW (Fig 9; Table 2). The mean size of females as in all the other offshore fishing areas varied between 111 and 122 mm CW (Fig. 9; Table 3). With the exception of October 1996 (10 %), the proportion of females in the catch was the highest during September and October (24 to 67 %) and remained lower between January and August (1 to 9 %).

In all fishing areas most males (45-98%) were greater than the legal size of 130 mm CW. The percentage of legal size males varied between fishing areas and between months within each fishing area. No trend was obvious. The monthly percentages of legal size male (>130 mm CW), was the highest on Georges Basin (90 and 98 %), and from August 1997 has remained high in Crowell Basin (between 81 and 94 %) (Table 2).

Variation in crab size composition between months and areas can be attributed partly to the lack of standardization for fisherman effect, soak time, trap type, exact area fished, and whether or not lobsters were caught in the same traps. In this evolving fishery there is a continuous movement of gear between and within assessment areas. As at-sea catch sampling data is now explicitly georeferenced, it should be possible to isolate some of these effects and examine temporal trends for specific geographical areas.

General biological information

No ovigerous females were observed during sampling in 1995 and less than 1% of the females sampled during 1996 and 1997 were ovigerous. However, from March to July 1998, and in March and April 1999, between 2 and 30% of the females sampled in Crowell Basin were carrying eggs. Percentages of berried females greater than 1% were also found on Southwest Browns in September 1998 (11%) and May 1999 (3%) and on Southeast Browns in January (4%), March (3%) and July 1998 (6 %). In all the sea samples obtained from Georges Bank and Georges Basin, no ovigerous females were found. The low occurrence of ovigerous females and of small or soft shell crab, is in part the result of a fishing practice of avoiding areas where high incidence of unwanted crabs occur in the catch.

Although at-sea sampling was conducted throughout the year, there was no obvious period when there was a high prevalence of soft-shell crab. Based on information provided by processing plants, the lowest meat yield for Jonah crab occurs during March and April on Southeast Browns Bank, and during October and November on Georges Bank. This is likely indicative of molting periods occurring at different times of year in different parts of the overall fishing area.

A recent study on size at maturity for Jonah crab from offshore Nova Scotia indicates that the size of functional maturity averaged 128 mm CW (Moriyasu et al., in prep). This size at maturity is much larger than the previous assumption of 110 mm CW (Benhalima et al., 1998). This new study challenges our previous assumption that female fecundity and subsequently recruitment is protected.

CONCLUSIONS

There are no fishery-independent surveys for this species, and this assessment is based on catch rates and size composition data from the commercial catch. Traps are highly selective and crustacean catchability is affected by a variety of factors

(Richards et al., 1983). The catch rate has not been standardized for fisher, trap type, area, season and if lobsters were caught in the same traps. Standardization would be difficult because the important variables are available for only a small subset of the data. Some of the variation in the catch rate and size composition probably results from factors other than the abundance of Jonah crab.

The Jonah crab by-catch fishery is relatively recent, and while most commercial grounds have been identifed, the fishery is still expanding into marginal areas. Thus, the introduction of the Jonah crab by-catch fishery has resulted in more widespread fishing activity within the traditional offshore lobster assessment areas. However, interpretation of Jonah crab catch rates is difficult since much of the fishing activity still revolves around the timing of the more lucrative lobster fishery (Pezzack et al., 2000). The crab fishery has complicated offshore fishery assessment, as trips can be directed for crab, for lobsters, or for both species. The amount of effort expended, and the fishing area to which it is directed depends on the availability of crab, the markets and the proportion of the lobster or crab TAC remaining (Pezzack et al., 2000).

During the last two years, there are concerns of a substantial increase in effort in the Crowell Basin, and southwest Browns areas by both the offshore Jonah crab fleet (LFA 41) and the adjacent inshore Jonah crab exploratory fishery (LFA 34). In addition, during the past several years, the inshore lobster fishery has harvested significant amounts of Jonah crab, landed as a by-catch (Robichaud et al., 2000). Processing plant information indicates that inshore lobster fishermen did not report a large amount of the Jonah crab by-catch landed.

While most of the more productive fishing grounds are exploited, marginal fishing grounds with lower catch rates continue to be explored. Changes in catch rates or effort may not be indicative of what the fishery can sustain. The decline in catch rate on Georges Bank can be partly attributed to a lower quality of fishing effort. During the last two years Jonah crab on Georges Bank has been fished more as a by-catch than a directed fishery as it was in previous years. Biological and fishery information obtained to-date indicates that a cautious approach should be taken to maintain a fishable stock. The catch rates, behavior of the fishery, and the size structure of the stock should continue to be monitored through logbooks, dockside monitoring and sea sampling.

As effort increases in the midshore exploratory Jonah crab fishery (LFA 34) and as Jonah crab by-catch increases during the lobster fishing season in the adjacent inshore lobster fishery, the Jonah crab by-catch in the inshore and midshore lobster fishery needs to be monitored and controlled.

ACKNOWLEDGMENTS

We thank captains of the offshore lobster fishing vessels for their cooperation in filling out voluntary science logs, plant owners and company representatives, and boat crews for their support of the at-sea sampling program. We thank W. Scott and M. Scott (III) for the many days they spent at sea collecting fishery information during some not so good weather. We also thank Mike Eagles for reviewing the manuscript.

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Table 1. Yearly landings and effort data summarized by lobster assessment areas for the offshore Jonah crab by-catch fishery.

Offshore Lobster Assessment areas	Fishing Seasons				
	1994-95	1995-96	1996-97	1997-98	1998-99
Crowell Basin					
Landings (t)		14	161	316	296
Effort (trap hauls)		3869	31631	70694	64220
CPUE (Kg/th)		3.5	5.1	4.5	4.6
Southwest Browns					
Landings (t)	6	25	74	70	168
Effort (trap hauls)	4277	15575	41099	33148	69206
CPUE (Kg/th)	1.4	1.6	1.8	2.1	2.4
Georges Basin					
Landings (t)		3	26	85	88
Effort (trap hauls)		1370	8800	29203	33975
CPUE (Kg/th)		2.2	2.9	2.9	2.6
Southeast Browns					
Landings (t)	2	84	125	136	99
Effort (trap hauls)	1100	30095	83363	58740	63751
CPUE (Kg/th)	1.9	2.8	1.5	2.3	1.5
Georges Bank					
Landings (t)	31	230	322	95	47
Effort (trap hauls)	6724	34379	79155	29600	21899
CPUE (Kg/th)	4.5	6.7	4.1	3.2	2.1
Total					
Landings (t)	39	356	707	702	697
Effort (trap hauls)	12101	85288	244048	221385	253051
CPUE (Kg/th)	3.2	4.2	2.9	3.2	2.8

Table 2. Monthly male Jonah crab carapace width statistics from sea samples for each lobster assessment area.

Fishing Area	Month/ Year	Number Sampled	Mean cw (mm)	Min-Max cw (mm)	S. E.	Percentage > 130 mm (cw)
Crowell Basin	Oct-96	752	129	70-180	0.80	59%
	Aug.-97	941	145	101-186	0.38	93%
	Mar-98	2870	142	70-176	0.21	89%
	May-98	3808	141	86-178	0.17	89%
	May-98b	2099	146	81-174	0.24	94%
	Jul-98	2879	144	103-179	0.20	92%
	Mar-99	3507	138	89-178	0.18	81%
	Apr-99	3449	138	91-176	0.17	83%
	Aug-99	1230	140	81-168	0.3	87%
Southwest Browns	Oct-95	4071	136	52-212	0.25	76%
	Jul-96	338	142	86-165	0.89	78%
	Aug-96	629	133	71-168	0.49	61%
	Oct-96	530	146	78-181	0.58	92%
	Aug-97	391	128	79-165	0.81	54%
	Oct-97	2858	135	76-180	0.24	71%
	Sep-98	1852	139	83-168	0.22	89%
	Oct-98	1594	140	83-168	0.22	92%
	May-99	1722	138	84-179	0.20	80%
Georges Basin	Apr-98	262	141	109-172	0.61	90%
	Aug-99	831	148	93-175		98%
Southeast Browns	Oct-95	2556	135	55-190	0.37	72%
	Jul-96	4197	136	45-180	0.20	76%
	Aug-96	3278	129	90-177	0.24	54%
	Sep-96	2552	137	84-179	0.23	82%
	Oct-96	668	136	77-170	0.46	77%
	Mar-97	1360	129	79-168	0.41	56%
	Jul-97	2611	140	61-197	0.24	86%
	Oct-97	1678	138	78-197	0.33	81%
	Jan-98	3353	135	91-186	0.22	71%
	Mar-98	3426	126	78-172	0.25	45%
	Apr-98	3986	133	87-166	0.21	65%
	Jul-98	2762	141	87-220	0.24	87%
Georges Bank	Oct-95	7829	140	41-188	0.15	85%
	Jul-96	1972	139	72-180	0.28	92%
	Aug-96	3081	142	76-174	0.28	91%
	Oct-96	1183	141	74-202	0.33	90%
	Nov-96	1477	136	69-175	0.40	75%
	Jan-97	1114	136	82-169	0.38	74%
	Feb-97	1863	140	85-222	0.26	86%
	Mar-97	2027	138	82-173	0.27	81%
	Jul-97	1094	135	50-172	0.60	75%
	Aug-97	3133	137	45-191	0.25	80%
	Oct-97	2858	135	76-180	0.24	71%
	Apr-98	1194	139	72-168	0.30	85%
	Oct-98	709	143	79-174	0.38	95%

Table 3. Monthly female Jonah crab carapace width statistics from sea samples for each lobster assessment area.

Fishing Area	Month/ Year	Number Sampled	Mean cw (mm)	Min-Max cw (mm)	S. E.	% Female in Catch
Crowell Basin	Oct-96	308	110	68-145	0.92	29
	Aug-97	333	126	102-186	0.48	26
	Mar-98	42	116	81-151	2.90	1
	May-98	49	113	86-145	2.30	1
	May-98b	33	123	83-144	2.54	2
	Jul-98	102	123	97-145	0.86	3
	Mar-99	103	121	90-141	0.94	3
	Apr-99	95	117	80-137	1.15	3
	Aug-99	1004	117	91-150	0.60	45
Southwest Browns	Oct-95	1584	118	64-156	0.33	28
	Jul-96	275	119	94-157	0.49	45
	Aug-96	312	119	76-135	0.91	33
	Oct-96	324	125	82-156	0.59	38
	Aug-97	390	105	75-147	0.71	50
	Oct. 97	1140	117	74-167	0.30	29
	Sep-98	635	116	82-147	0.46	26
	Oct-98	559	118	85-146	0.41	26
	May-99	213	116	81-141		11
Georges Basin	Apr-98	5	107	89-130	7.70	2
	Aug-99	122	124	93-138		13
Southeast Browns	Oct-95	1827	118	66-178	0.33	42
	Jul-96	314	113	86-135	0.53	7
	Aug-96	503	111	89-153	0.40	13
	Sep-96	437	113	76-163	0.55	15
	Oct-96	125	115	79-142	1.00	16
	Mar-97	74	110	73-142	2.01	5
	Jul-97	1084	119	72-188	0.33	29
	Oct-97	1845	117	84-154	0.29	52
	Jan-98	46	120	95-136	1.50	1
	Mar-98	350	116	82-153	0.63	9
	Apr-98	58	114	90-141	1.78	1
	Jul-98	824	123	84-143	0.33	23
Georges Bank	Oct-95	6181	117	40-178	0.12	44
	Jul-96	130	115	77-134	0.94	6
	Aug-96	67	119	96-134	1.21	2
	Oct-96	335	119	83-170	0.54	22
	Nov-96	459	116	69-175	0.53	24
	Jan-97	67	118	96-134	1.03	6
	Feb-97	40	116	96-129	1.39	2
	Mar-97	57	111	90-130	1.49	3
	Jul-97	111	109	72-136	1.56	9
	Aug-97	137	108	72-137	1.15	4
	Oct-97	1140	117	74-167	0.30	29
	Apr-98	16	118	82-134	3.60	1
	Oct-98	1425	122	87-160	0.17	67

Figure 1. Map showing the five offshore lobster assessment areas.

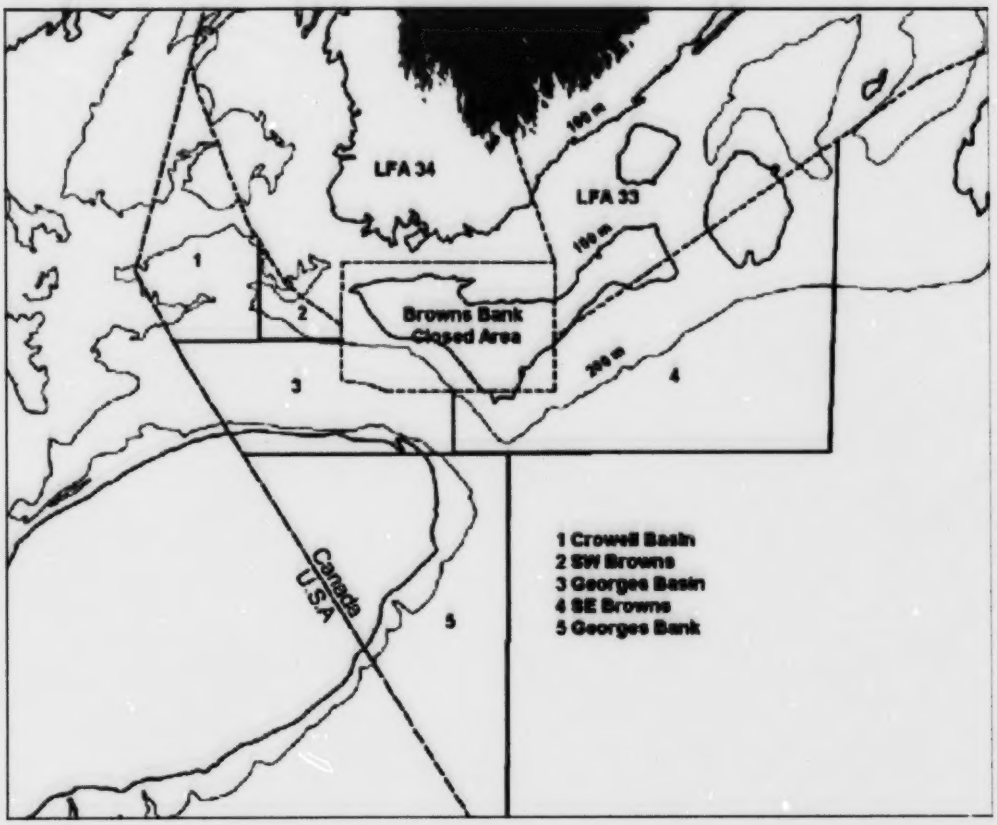


Figure 2. Map showing the distribution of Jonah crab landings (kg) by ten minutes grids (1995 to 1999).

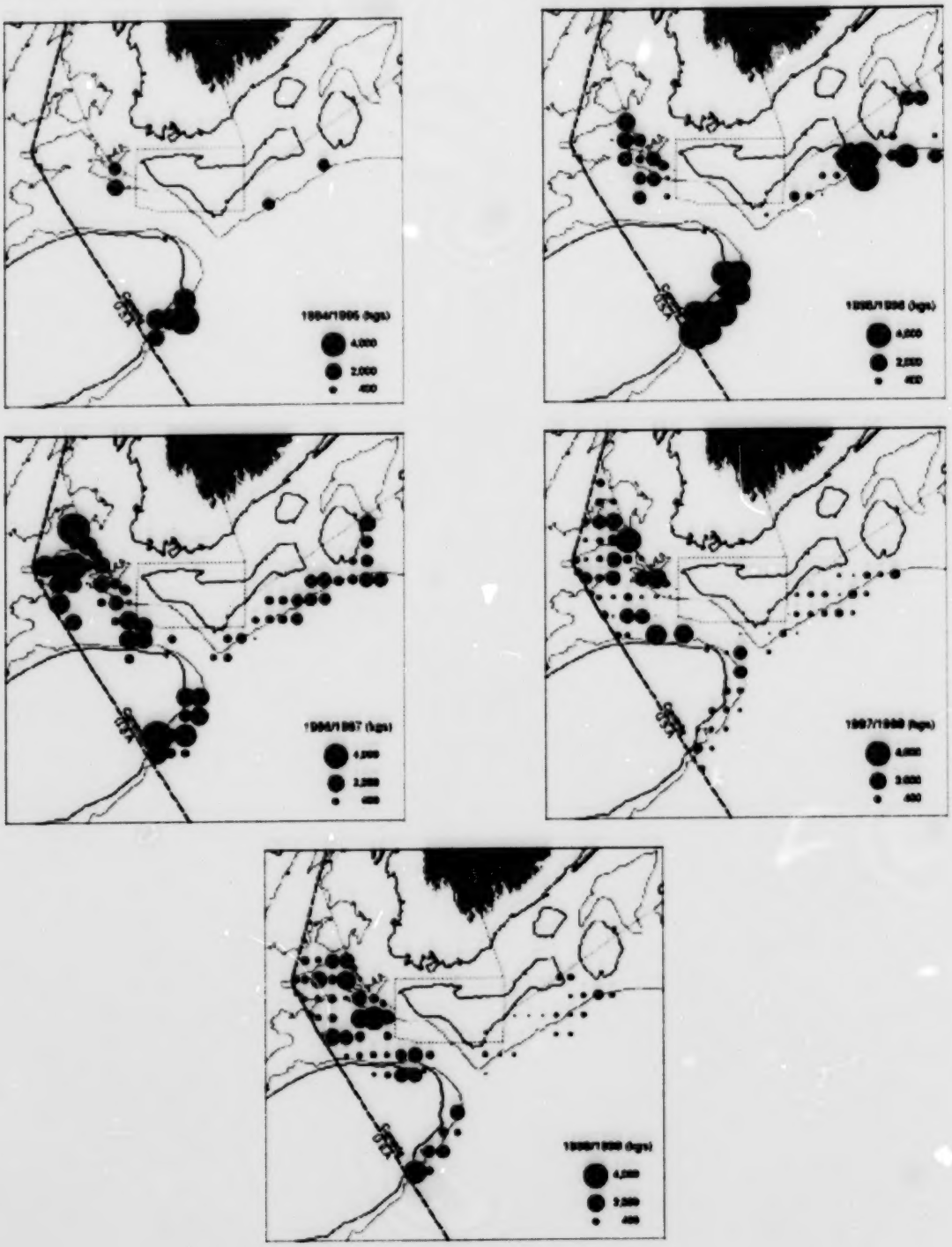
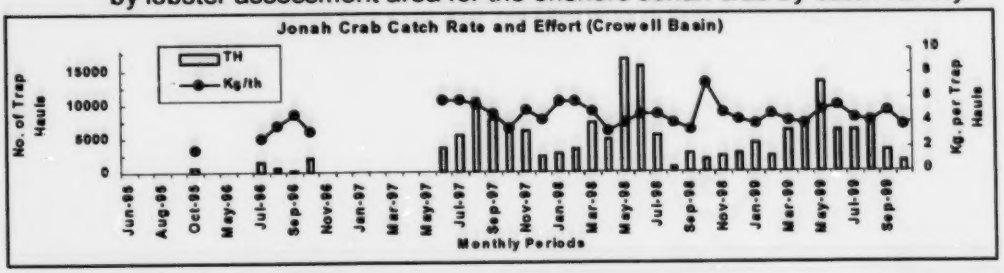
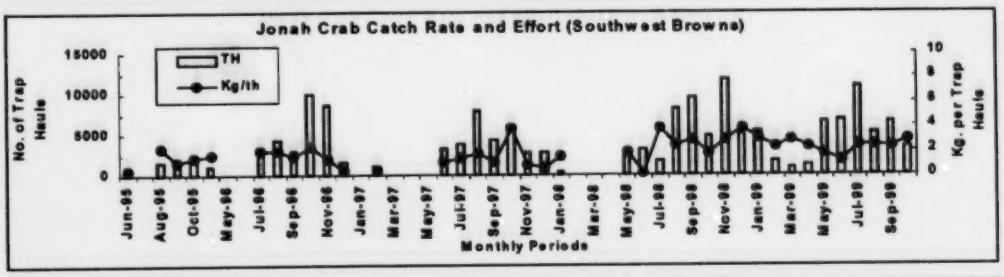
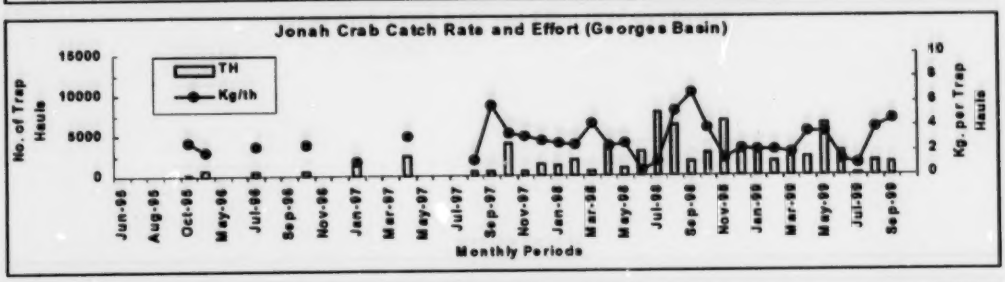
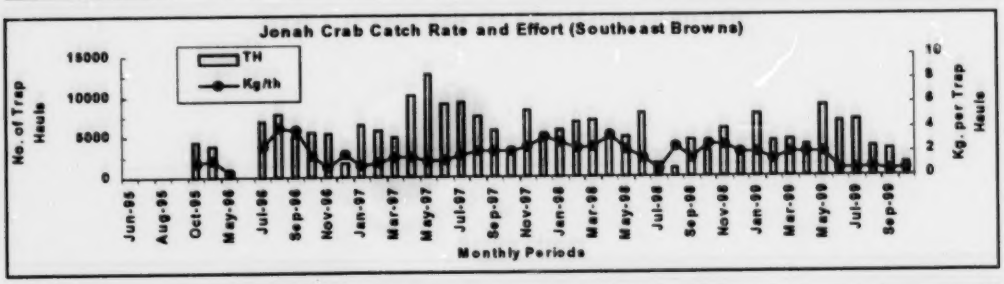


Figure 3. Evolution of monthly effort (trap hauls) and catch rate (kg/th) summarized by lobster assessment area for the offshore Jonah crab by-catch fishery.









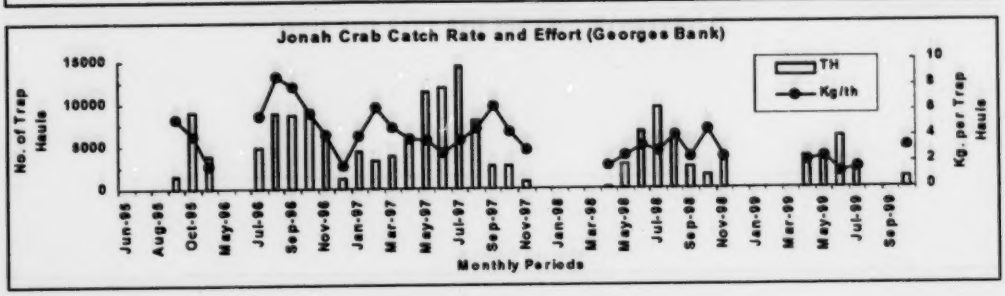
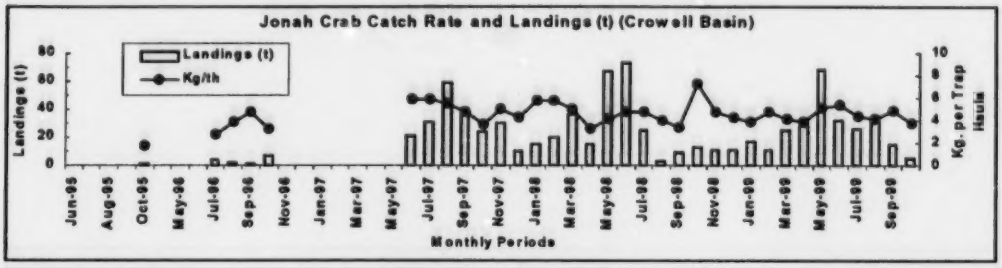
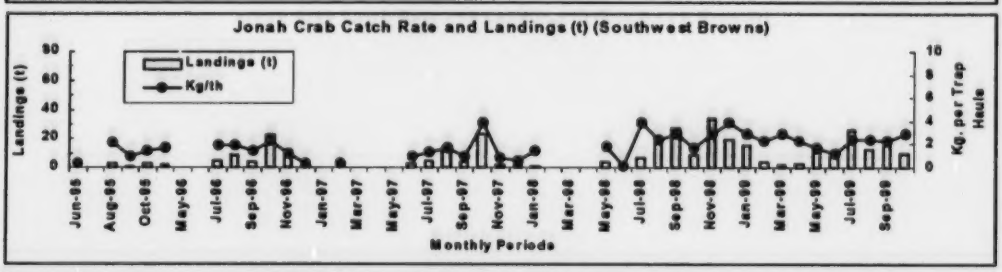
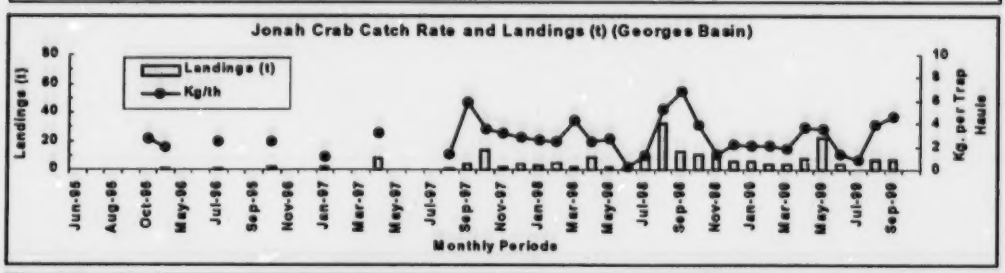
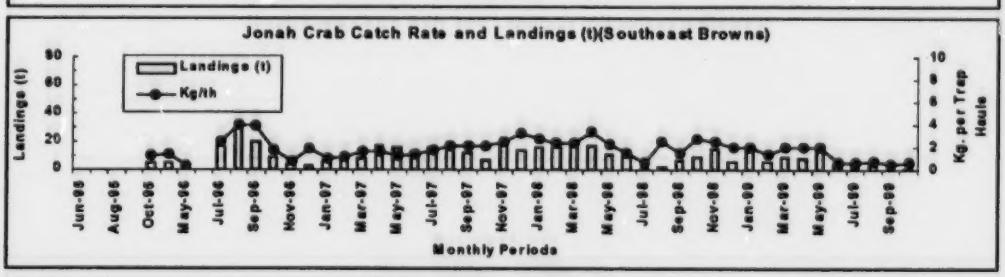


Figure 4. Evolution of monthly landings (t) and catch rate (kg/th) summarized by lobster assessment areas for the offshore Jonah crab by-catch fishery.









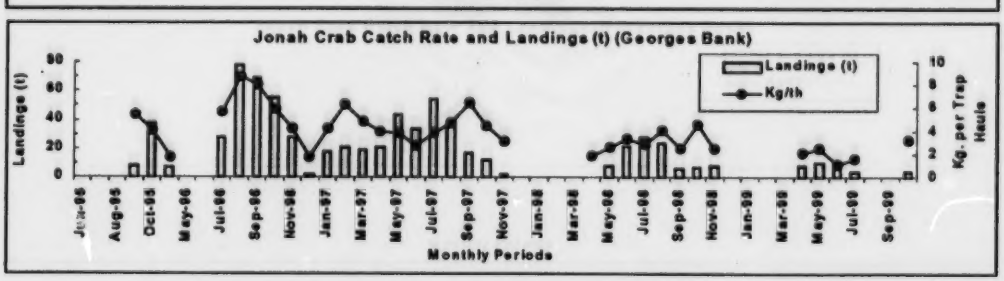


Figure 5. Size frequencies (1 mm CW size classes) of males (dark histograms) and females (light histograms) Jonah crab from sea samples taken on Crowell Basin, October 1995- August 1999.

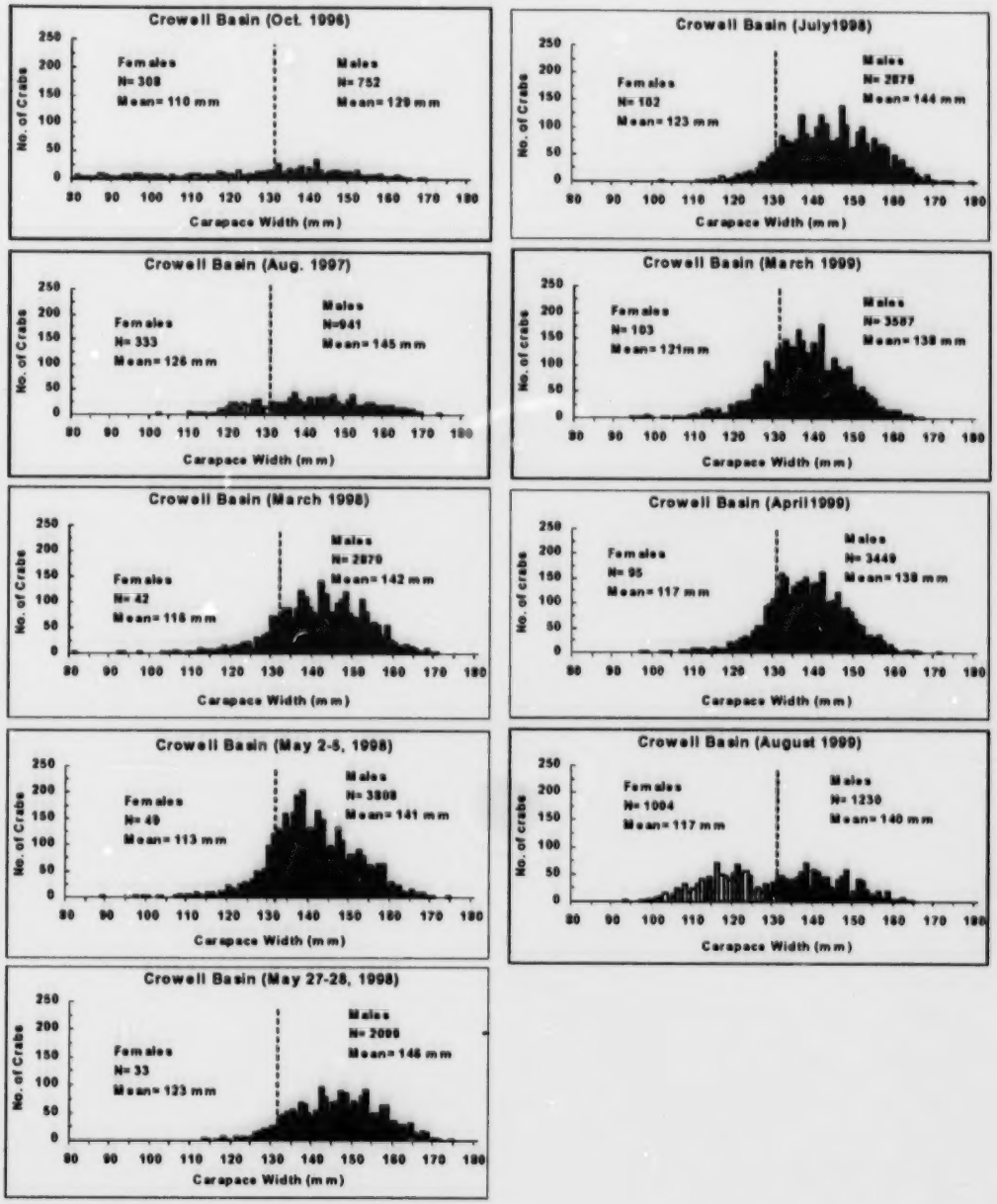


Figure 6. Size frequencies (1 mm CW size classes) of males (dark histograms) and females (light histograms) Jonah crab from sea samples taken on Southwest Browns Bank, October 1995- May 1999.

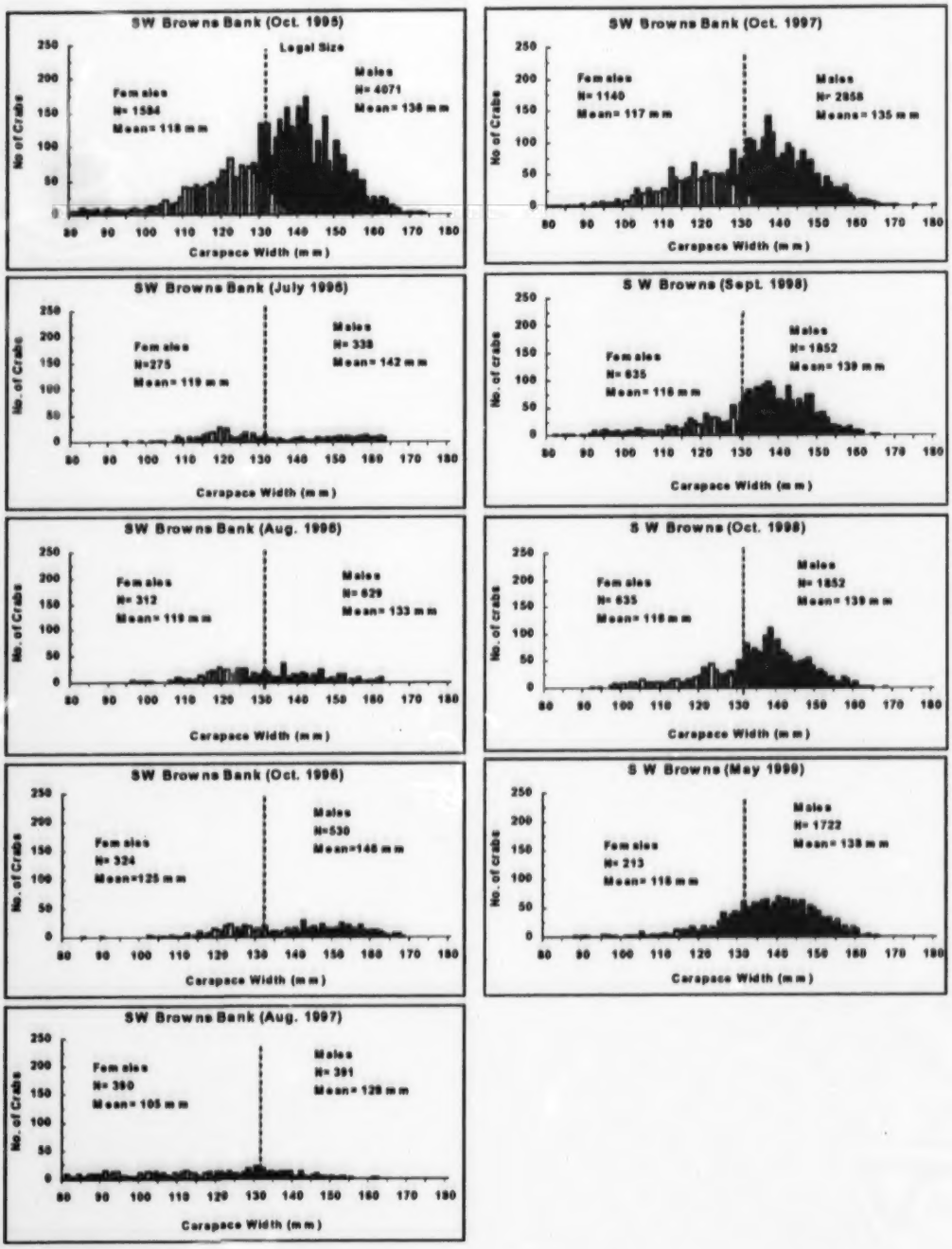


Figure 7. Size frequencies (1 mm CW size classes) of males (dark histograms) and females (light histograms) Jonah crab from sea samples taken on Georges Basin, April 1998 and August 1999.

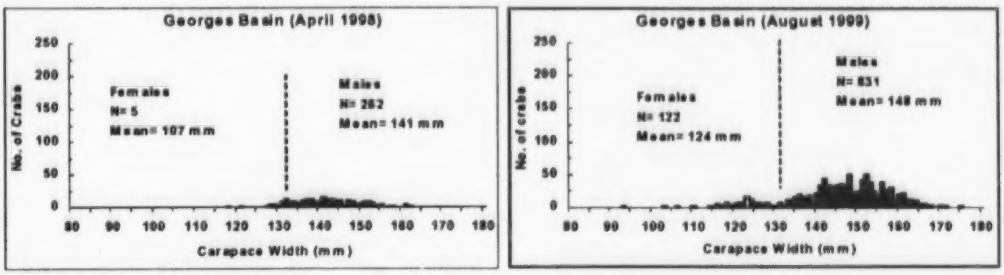


Figure 8. Size frequencies (1 mm CW size classes) of males (dark histograms) and females (light histograms) Jonah crab from sea samples taken on Southeast Browns Bank, October 1995- July 1998.

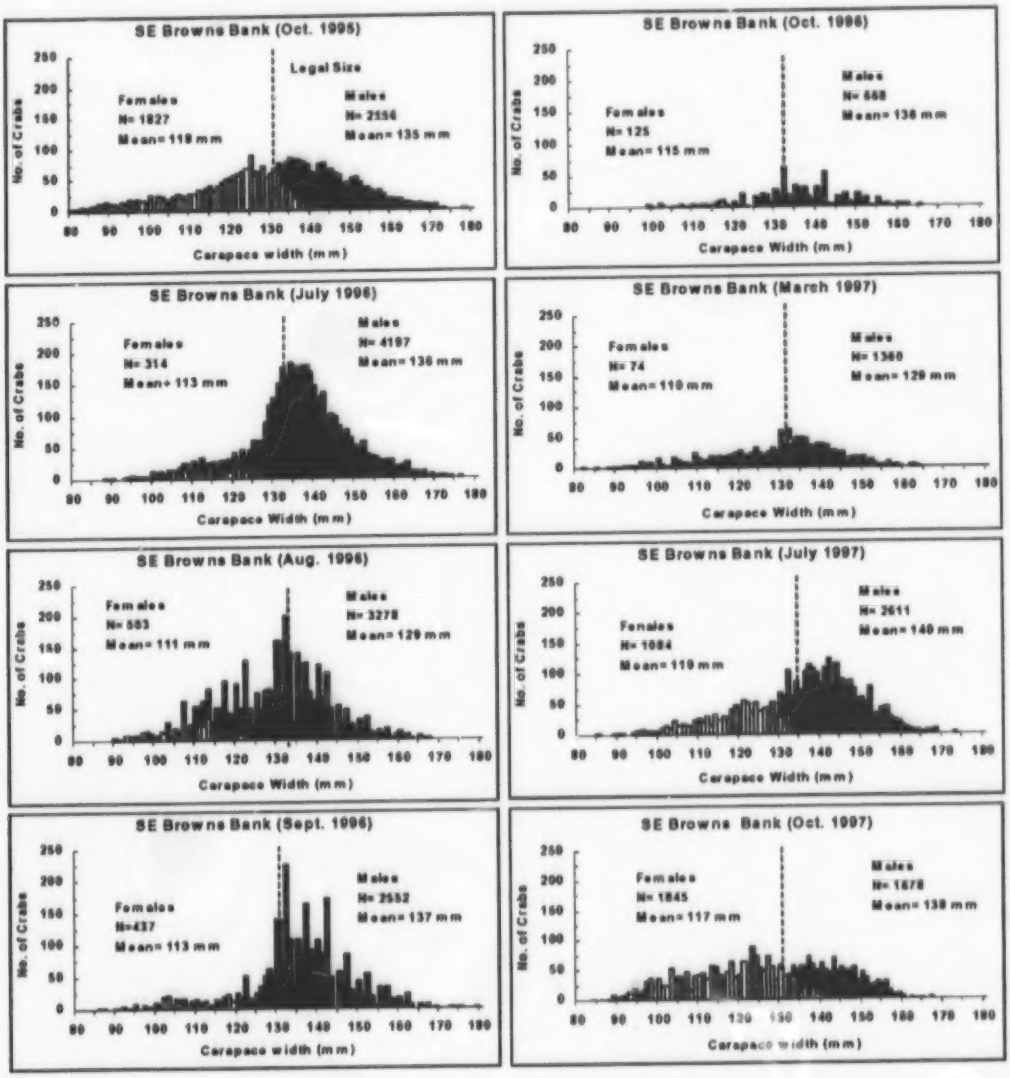


Figure 8. Continue

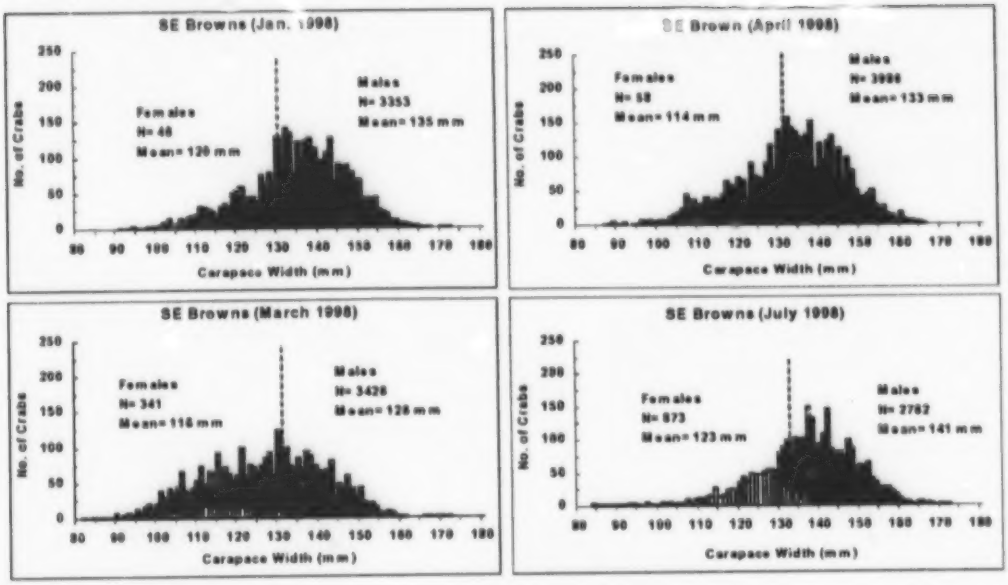


Figure 9. Size frequencies (1 mm CW size classes) of males (dark histograms) and females (light histograms) Jonah crab from sea samples taken on Georges Bank, October 1995- October 1998.

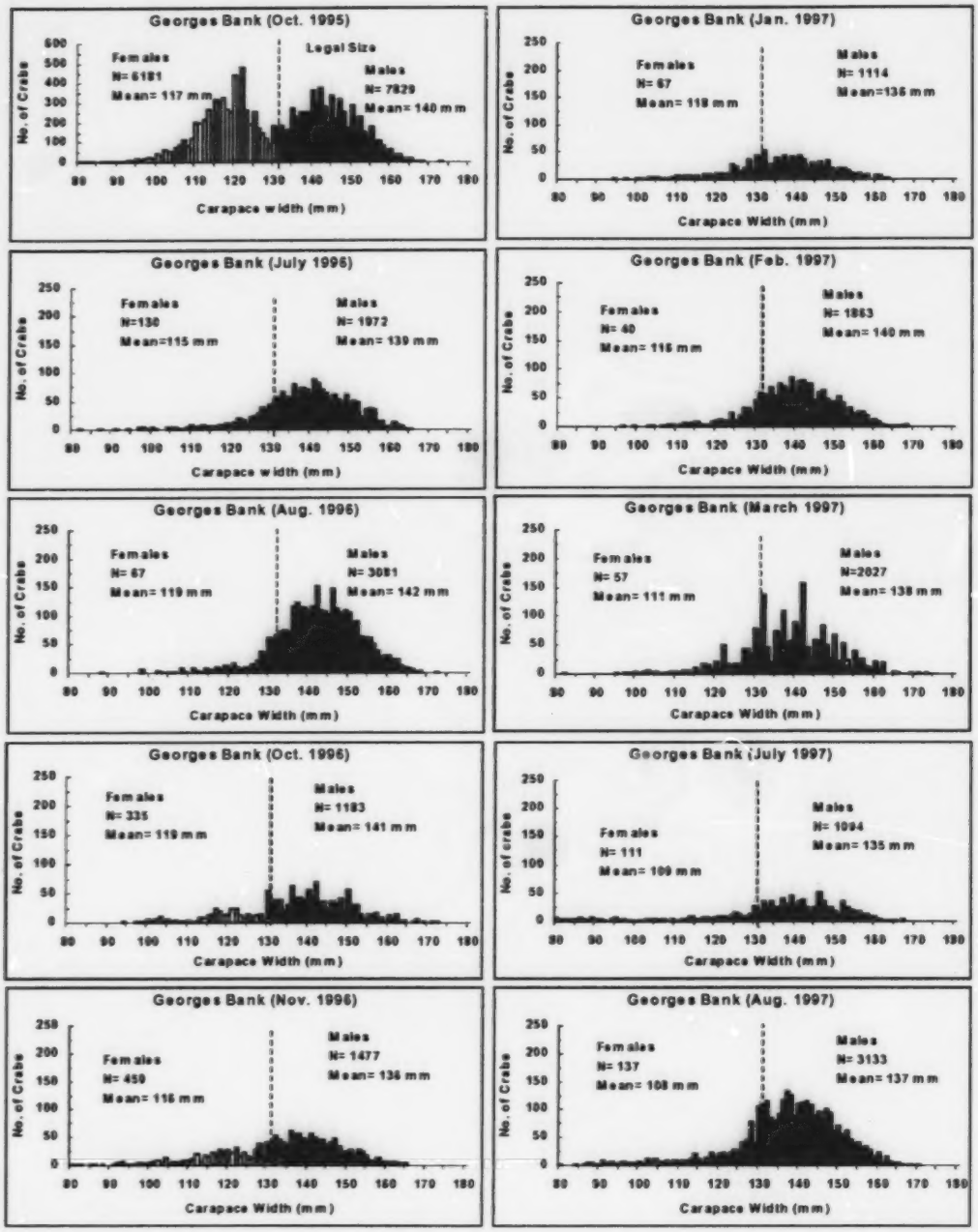
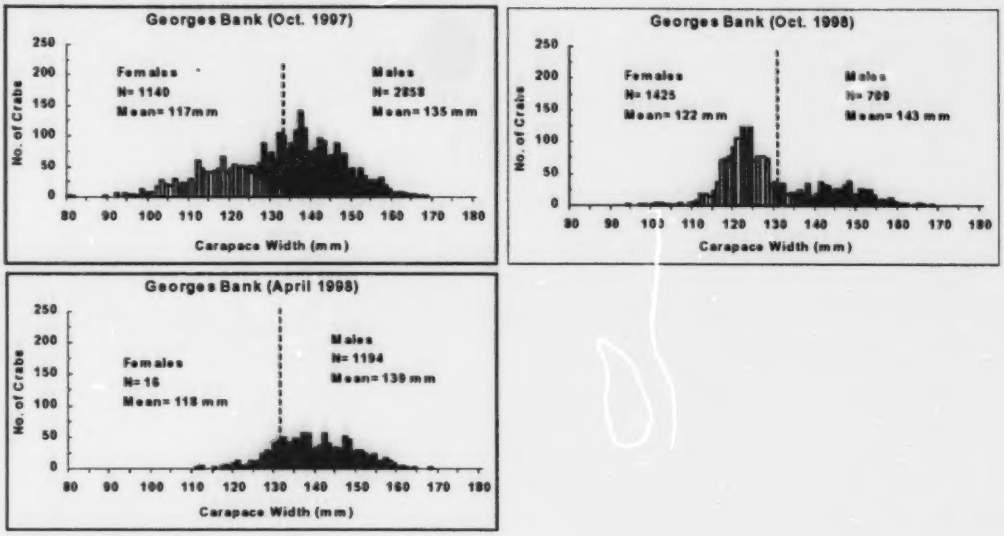


Figure 9. Continue.



Appendix 1. History and Development of the Scotian Shelf Jonah Crab Fishery.

mid-60's -Jonah crab exploited at minimal levels as by-catch to lobster fishery.

1966 -Canadian trawl survey from Sable Island Bank to Georges Bank.
-Few Jonah crabs were found.

1969-1971 -Trapping survey by N. S. Dept. of Fisheries along Continental Slope from Sable Island Bank to Browns Bank.
-Similar results to 1966 trawl survey.
-Commercial concentrations of offshore lobsters were found.

1978 -Canadian trap survey along Continental Slope from Sable Island Bank to Georges Bank (conical top-entry traps).
-No commercial concentrations of Jonah crab was found.

1980-1981 -Canadian trap survey along Continental Slope from Emerald Bank to Fundian Channel.
-Five different types of traps were used.
-Catches were best in large offshore traps.
-No commercial concentrations of Jonah crab was found.

1981 -Alaskan crab stocks collapse resulting in increase in world market demand and price for crab.
-October - DFO fosters industry interest in a directed Jonah crab fishery along the Scotian Shelf.

1983 -January - Scotian Shelf Crab Advisory Committee was formed
-March: Following are recommendations made for Jonah crab permits:
-fish at least 12 miles from coast to 200 mile limit, and from 64°.30 to 65°63W,
-minimum size of 130 mm carapace width,
-all crabs to be landed in live, whole condition,
-no restriction regarding quotas, gear, sex (including berried females) or season,
-detailed log records were to be kept,
-by-catch of Jonah crab from other directed fisheries was allowed to be landed & sold.
-May: 32 Jonah crab permits were released.
-Pilot Jonah crab fishery (with a by-catch of Red Crab) began.
-Traps were set in LaHave and Emerald Basins and along the Scotian Shelf edge adjacent to these basins.
-Log records show landings, from three major fishing grounds, totaled **90t** from fishermen who actively fished only 10 permits.

Appendix 1 (continued).

1984 -No changes to regulations.
-August: Jonah crab fishery ceased due to gear conflicts and substantial gear loss.
-Two vessels direct exclusively for Red crab.
-Log records showed that Jonah crab landings from the Scotian Shelf edge only totaled **93t**, (sales slips indicated **149t** had been sold from the 3 active permits holders.

1985-93 -No further commercial activity.

1994-1995 -May: Offshore lobster industry request permission to land Jonah crab as by-catch.
-Permission was given with the following conditions:
- landings not to exceed the 720 TAC for lobsters,
- 130 mm carapace width minimum size, male only,
- 100% dockside monitoring,
- industry funded sea sampling and data entry,
- no trap limit,
- season same as for offshore lobster (Oct. 16 to next Oct. 15).

1995-1996 -No changes to regulations.
-Science logs required.
-One vessel was fishing mostly Jonah crab.

1996-1997 -No changes to regulations.

1997-1998 -No changes to regulations.

1998-1999 -No changes to regulations.